KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES

COMMON TEST

JUNE 2021

MARKS :75

TIME :1 ½ hours

This question paper consists of 7 pages and 3 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of SIX questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave ONE line between two subquestions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions, et cetera where required.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A-D) next to the question number (1.1-1.6) in the ANSWER BOOK, for example 1.11 D.

1.1 A girl carries a heavy suitcase up a flight of stairs. A boy of the same weight carries the same suitcase slowly up the flight of stairs. Which ONE of the following statements is TRUE?

A. The girl did lesser work and has lesser power than the boy

B. The girl has lesser power than the boy

C. The girl did more work and has more power than the boy

D. The girl did the same amount of work as the boy, and has more power than the boy (2)

1.2 The kinetic energy of object X is E. Object Y has double the mass of X and moves with twice the velocity of X. The kinetic energy of Y is …

A. 2E

B. 4E

C. 6E

D. 8E (2)

1.3 The wavelengths of light emitted by a distant star appear shorter when observed from Earth. From this we can conclude that the star is …

A. moving towards Earth and the light is blue shifted.

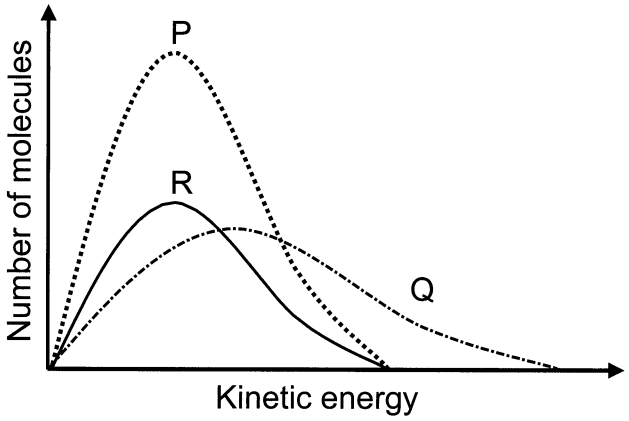
B. moving towards Earth and the light is red shifted.

C. moving away from Earth and the light is red shifted.

D. moving away from Earth and the light is blue shifted. (2)

1.4 Three energy distribution curves for oxygen gas under different conditions are shown in the graph below.

Curve R represents the energy distribution for 1 mole of oxygen gas at 30 °C.



Consider the following statements:
I. Curve P represents 1 mole of oxygen gas at 45 °C.
II. Curve P represents 2 moles of oxygen gas at 30 °C.
III. Curve Q represents 1 mole of oxygen gas at 45 °C.
IV. Curve Q represents 2 moles of oxygen gas at 30 °C.

Which of the above statements are TRUE?

A I and III.

B I and IV.

C II and III.

D II and IV

(2)

1.5 Chromate ions, $CrO_4^{2-}(aq)$ and dichromate ions, $Cr_2O_7^{2-}(aq)$ are in equilibrium in an aqueous solution according to the following balanced equation:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(\ell)$$
yellow orange

Which ONE of the following concentrated solutions should be added to make the colour of the solution orange?

A NaOH

B NH_3

C $Cr_2O_7^{2-}$

D $HC\ell$

(2)

1.6 The balanced equation below represents the first step in the ionisation of sulphuric acid in water:

$$H_2SO_4(\ell) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HSO_4^-(aq)$$

The two BASES in the above reaction are:

A $H_2SO_4(\ell)$ and $H_2O(\ell)$

B $H_3O^+(aq)$ and $HSO_4^-(aq)$

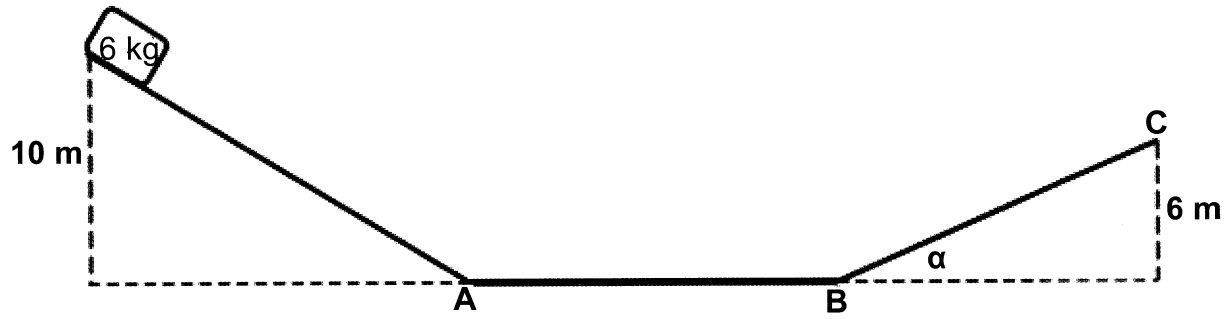
C $H_2O(\ell)$ and $HSO_4^-(aq)$

D $H_2SO_4(\ell)$ and $H_3O^+(aq)$

(2)
[12]

QUESTION 2

A 6 kg block starts from rest from a height of 10 m and slides down a smooth incline plane to point A. It then moves along a smooth horizontal portion AB and finally moves up a second ROUGH inclined plane BC. It stops at point C which is 6 m above the horizontal.



The frictional force between the surface and the block is 20 N as it moves from B to C.

2.1 State the principle of conservation of mechanical energy in words. (2)

2.2 Using Energy Principles, determine the magnitude of the velocity of the block at point A. (4)

2.3 State the work energy theorem in words (2)

2.4 Draw a labelled free body diagram for the block as it moves up the incline BC. (3)

2.5 Using Energy Principles, determine the length of path BC. (5)

[16]

QUESTION 3

A bird is flying in the air above and emits sound waves with a frequency of 1250 Hz. A stationary birdwatcher hears the sound waves at a frequency of 1290 Hz. Take the speed of sound in air to be 340 $m \cdot s^{-1}$.

3.1 State the Doppler Effect in words (2)

3.2 Is the bird flying towards or away from the birdwatcher? (1)

3.3 Calculate the speed of the bird. (5)
[8]

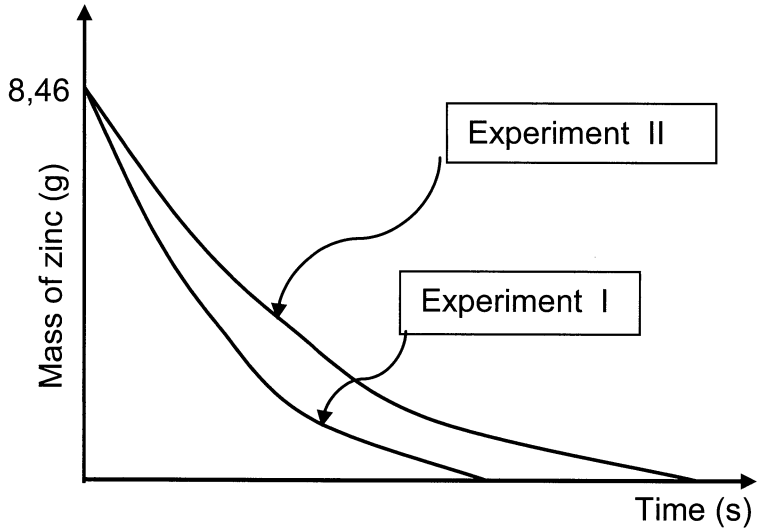
QUESTION 4

A group of learners use the reaction of zinc granules and sulphuric acid to investigate the effect of concentration on reaction rate. The balanced equation for the reaction is:

$$Zn\,(s) + H_2SO_4\,(aq) \rightarrow ZnSO_4\,(aq) + H_2\,(g)$$

Two experiments, I and II, were conducted using 8,46 g of zinc. The concentration of sulphuric acid was different for each experiment.

The sketch graph below shows the mass of zinc remaining in the flasks as the reactions proceeded.



4.1 Define the term *reaction rate*. (2)

4.2 Which reactant was in excess? (1)

4.3 In experiment I, 1,8816 dm^3 of hydrogen gas was collected at STP in the first minute of the reaction.

4.3.1 Calculate the mass of zinc remaining in the flask after one minute (5)

4.3.2 Calculate the rate of reaction (in $g \cdot s^{-1}$) at one minute (2)

4.4 Which experiment, I or II, used a higher concentration of sulphuric acid? (1)

4.5 Explain, with reference to the Collision Theory, the effect of concentration on reaction rate (4)
[15]

QUESTION 5

5.1 The thermal decomposition of calcium carbonate ($CaCO_3$) reaches equilibrium in a sealed container. The reaction is represented by the following equation:

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

5.1.1 State Le Chatelier's principle. (2)

The volume of the container is now decreased at constant temperature. How will each of the following be affected when a new equilibrium is established?
Write down only INCREASES, DECREASES or REMAINS THE SAME.

5.1.2 The concentration of $CO_2(g)$. (1)

5.1.3 The number of moles of $CaCO_3(s)$.
Explain the answer (3)

5.2 Initially 4 moles of $SO_2(g)$ and 5,50 moles of $O_2(g)$ are mixed in a sealed 2 dm^3 container. When the reaction reaches equilibrium at 427 °C, 4 moles of $O_2(g)$ is present in the container.
The balanced equation for the reaction is:

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g) \quad \Delta H < 0$$

Calculate the Kc value for this reaction at 427 °C. (7)
[13]

QUESTION 6

6.1 When oxalic acid $(COOH)_2$ crystals are added to water it ionises according to the following balanced equation:

$$(COOH)_2(s) + 2H_2O(\ell) \rightleftharpoons (COO)_2^{2-}(aq) + 2H_3O^+(aq)$$

6.1.1 Why is oxalic acid considered to be a weak acid? (1)

6.1.2 Some sodium oxalate crystals, $Na_2(COO)_2$, are now added to the solution above. How will the pH of the solution be affected?
Choose from: INCREASES, DECREASES or REMAINS THE SAME (2)

6.2 Learners add 50 cm^3 of hydrochloric acid solution of concentration 0,1 $mol{\cdot}dm^{-3}$ to 25 cm^3 of sodium hydroxide solution of concentration 'x' $mol.dm^{-3}$.

The concentration of the hydronium ions in the resulting 75 cm^3 solution is found to be 0,0461 $mol{\cdot}dm^{-3}$.

$$HC\ell\,(aq) + NaOH\,(aq) \rightleftharpoons NaC\ell\,(aq) + H_2O\,(\ell)$$

6.2.1 State the Lowry-Bronsted definition of an acid (1)

6.2.2 Calculate the concentration 'x' of the sodium hydroxide solution. (7)
[11]

TOTAL : 75

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

TABLE 1: PHYSICAL CONSTANTS / TABEL 1: FISIESE KONSTANTES

NAME / NAAM	SYMBOL / SIMBOOL	VALUE / WAARDE
Acceleration due to gravity *Swaartekragversnelling*	g	$9,8\ m\cdot s^{-2}$
Universal gravitational constant *Universele gravitasiekonstante*	G	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3,0 \times 10^{8}\ m\cdot s^{-1}$
Planck's constant *Planck se konstante*	h	$6,63 \times 10^{-34}\ J\cdot s$
Coulomb's constant *Coulomb se konstante*	k	$9,0 \times 10^{9}\ N\cdot m^2\cdot C^{-2}$
Charge on electron *Lading op electron*	e^-	$-1,6 \times 10^{-19}\ C$
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31}\ kg$
Mass of Earth *Massa van Aarde*	M	$5,98 \times 10^{24}\ kg$
Radius of Earth *Radius van Aarde*	R_E	$6,38 \times 10^{6}\ m$

TABLE 2: FORMULAE / TABEL 2: FORMULES

MOTION / BEWEGING

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or/of $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^{\ 2} = v_i^{\ 2} + 2a\Delta x$ or/of $v_f^{\ 2} = v_i^{\ 2} + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ or/of $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$

FORCE / KRAG

$F_{net} = ma$	$p = mv$
$f_{s(max)} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \frac{Gm_1m_2}{r^2}$	$g = \frac{GM}{r^2}$

WORK, ENERGY AND POWER / ARBEID, ENERGIE EN DRYWING

$W = F\Delta x\cos\theta$	$U = mgh$ or/of $E_P = mgh$
$K = \frac{1}{2}mv^2$ or/of $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ or/of $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or/of $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or/of $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{av} = F \cdot v_{av}$ / $P_{gem} = F \cdot v_{gem}$	

WAVES, SOUND AND LIGHT / GOLWE, KLANK EN LIG

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$	$E = hf$ or/of $E = h\frac{c}{\lambda}$
$E = W_o + E_{k(max)}$ or/of $E = W_o + K_{(max)}$ where/waar $E = hf$ and/en $W_o = hf_o$ and/en $E_{k(max)} = \frac{1}{2}mv^2_{max}$ or/of $K_{(max)} = \frac{1}{2}mv^2_{max}$	

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

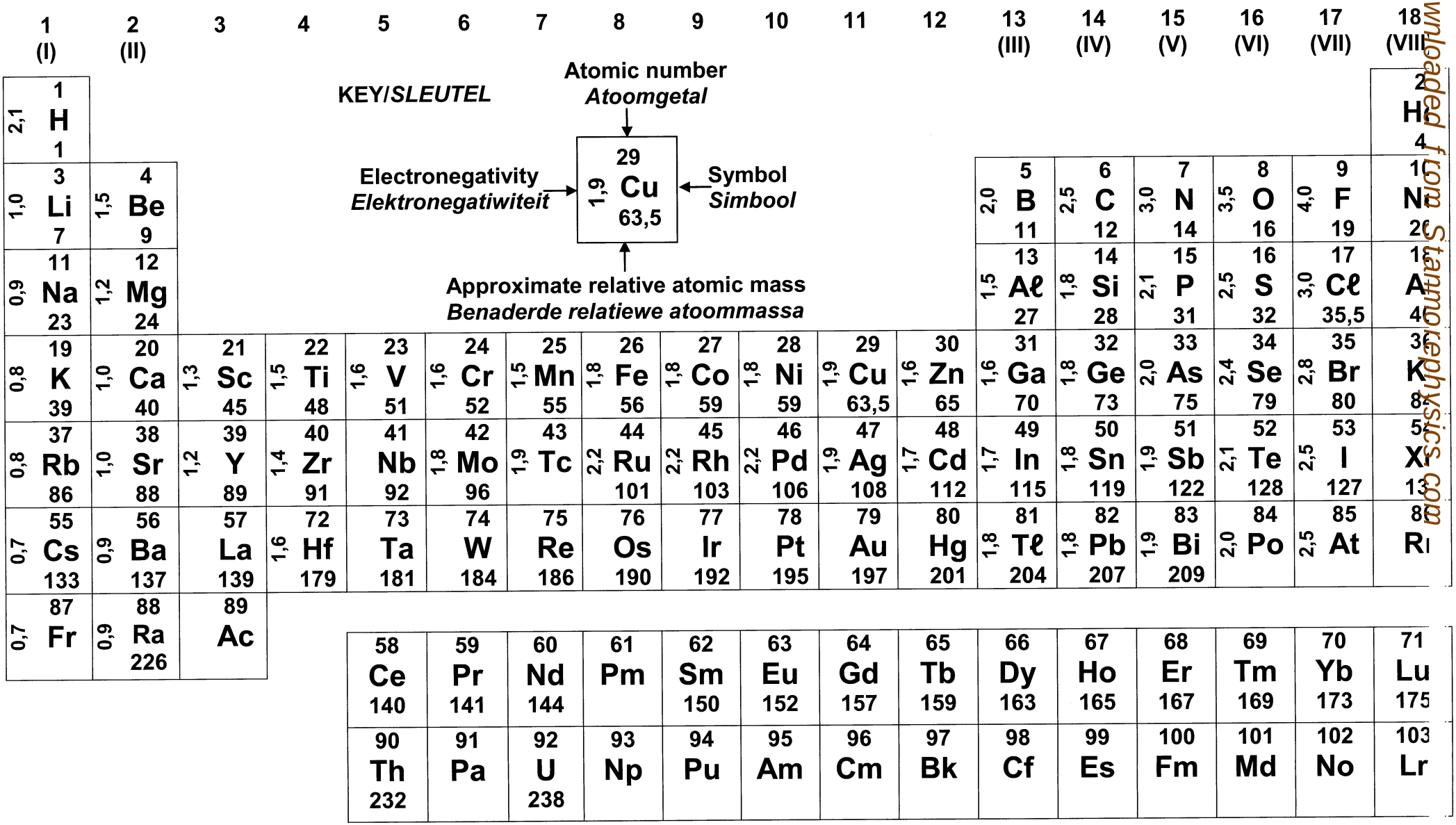
TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^θ	273 K
Charge on electron *Lading op electron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
BEL 3: DIE PERIODIEKE TABEL VAN ELEMEN



education

Department:
Education
PROVINCE OF KWAZULU-NATAL

NATIONAL
SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES

JUNE 2021

MARKING GUIDELINE

MARKS: 75

This marking guideline consists of 6 pages.

QUESTION 1

1.1 D✓✓ (2)

1.2 D✓✓ (2)

1.3 A✓✓ (2)

1.4 C ✓✓ (2)

1.5 D ✓✓ (2)

1.6 C ✓✓ (2)

[12]

QUESTION 2

2.1 The <u>total mechanical energy</u> (sum of gravitational potential energy and kinetic energy) in an <u>isolated system</u> <u>remains constant</u>. ✓✓ (2)

2.2 E_{mech} at the start = E_{mech} at A ✓

$(mgh + ½ mv^2)_{start} = (mgh + ½ mv^2)_A$

$(6)(9,8)(10) + ½ (6)(0^2)$✓ $= (6)(9,8)(0) + ½ (6)v^2$ ✓

$v = 14,00 \text{ m·s}^{-1}$ ✓

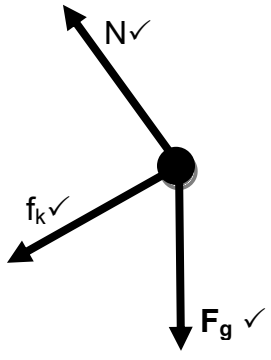
(4)

2.3 The <u>net/total work done</u> on an object is <u>equal to</u> the <u>change in the object's kinetic energy</u> ✓✓

OR

The <u>work done on an object by a resultant/net force</u> <u>is equal</u> to <u>the change in the object's kinetic energy</u>. ✓✓ (2)

2.4



	Accept the following symbols
N✓	F_N/Normal/Normal force
f_k✓	Kinetic friction force/f/F_f/f_r
F_g✓	w/58,8N

Notes
- Mark is awarded for label and arrow.
- Do not penalise for length of arrows.
- Deduct 1 mark for any additional force.
- If force(s) do not make contact with body/dot : *Max:2/*3
- If arrows missing but labels are there: *Max:2/*3

(3)

2.5 OPTION 1

$W_{net} = \Delta E_K$ ✓
$W_f + W_g + W_N = \Delta E_K$
$f_k \Delta x \text{Cos}180^o + mgh + 0 = ½mv_f^2 - ½mv_i^2$
$\underline{20\Delta x\cos 180^o}$ ✓ - $\underline{6x9,8x6}$ ✓ = $\underline{½(6)(0) - ½(6)(14)^2}$ ✓
$\Delta x = 11,76$ m ✓
∴ The length of BC is 11,76 m

OPTION 2

$W_{net} = \Delta E_K$ ✓
$W_f + W_g + W_N = \Delta E_K$
$f_k \Delta x \text{Cos}180^o + F_g \Delta x \text{Cos}(270^o + \alpha) + 0 = ½mv_f^2 - ½mv_i^2$
$20\Delta x \text{Cos}180^o + (6)(9,8)(\Delta x)(-\text{Sin}\ \alpha) = ½(6)v_f^2 - ½(6)(14)^2$
$\underline{20\Delta x \text{Cos}180^o}$ ✓ + $\underline{(6)(9,8)(\Delta x)(\ 6/\Delta x)}$ ✓ = $\underline{½(6)(0) - ½(6)(14)^2}$ ✓
$\Delta x = 11,76$ m ✓
∴ The length of BC is 11,76 m

OPTION 3

$W_{nc} = \Delta Ek + \Delta Ep$ ✓
$W_f = \Delta Ek + \Delta Ep$
$\underline{20 \times \Delta x \cos 180^o}$ ✓ = 0 - $\underline{½(6)(14)^2}$ ✓ + $\underline{(6-0)(9,8 \times 6)}$ ✓
$\Delta x = 11,76$ m ✓
∴ The length of BC is 11,76 m

NB: If equations of motion are used award =(1/5) (5)
[16]

QUESTION 3

3.1 The change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓

OR

It is the change in the observed frequency of a sound wave when the source of sound is moving relative to the listener. ✓✓ (2)

3.2 Towards✓ (1)

3.3 $f_L = \frac{v \mp v_L}{v \mp v_S} f_s$ ✓

1290✓ $= (\frac{340}{340 - v_S})$✓$1250$✓

v_s = 10,54 m·s^{-1} ✓

(5)

[8]

QUESTION 4

4.1 Change in concentration/mass/amount ✓ of reactants/products per unit time. ✓

OR

Rate of change in concentration/mass/amount of reactants/products✓✓ (2)

4.2 Sulphuric Acid / H_2SO_4✓ (1)

4.3.1 $n = \frac{V}{V_m}$

$= \frac{1,8816}{22,04}$ ✓

= 0,084 mol

$\therefore n\ Zn = 0,084\ mol$ ✓

Mass = n x RM
= 0,084 x 65 ✓
=5,46g

Mass remaining = 8, 46 – ✓5,46
= 3 g ✓

(5)

4.3.2 ***Positive marking from 4.3.1*** (2)

Rate = $\frac{5,46}{60}$ ✓ $= 0,09\ g.s^{-1}$ ✓ (0,091)

4.4 Experiment I✓ (1)

4.5
- Increase in concentration increases the number of particles per unit volume.✓
- increase in number of collisions per unit time.✓
- increase in number of effective collisions per unit time.✓
- increase in reaction rate.✓

OR

- Decrease in concentration decreases the number of particles per unit volume.✓
- Decreases in number of collisions per unit time.✓
- Decreases in number of effective collisions per unit time.✓
- Decreases in reaction rate.✓ (4)

[15]

QUESTION 5

5.1.1 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance. ✓✓ (2)

5.1.2 increases. ✓ (1)

5.1.3 Increases✓

- Increase in pressure favours the reaction that decreases the number of moles of gas. ✓
- Reverse reaction is favoured✓ (3)

5.2

Marking criteria:

- Calculating the quantity -1,5 mol✓
- Correct mol ratio✓
- Calculating the quantity(mol) at equilibrium of all three substances ✓
- Substitute V = 2 dm^3 to determine concentration at equilibrium of all the substances.✓
- K_c expression✓
- Substitution into K_c expression ✓
- Final answer 4,5✓

	SO_2	O_2	SO_3	
Ratio	2	1	2	
Initial quantity (mol)	4	5,5	0	
Change (mol)	-3	-1,5✓	+3	Using ratio ✓
Quantity at equilibrium (mol)	1	4	3	✓
Equilibrium concentration ($mol \cdot dm^{-3}$)	0,5	2	1,5	Divide by 2 ✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark$$

$$\therefore = \frac{(1,5)^2}{(0,5)^2(2)} \checkmark$$

$$= 4,5 \checkmark$$

No K_c expression, correct substitution. $^6/_7$

Wrong K_c expression $^4/_7$

(7)

[13]

QUESTION 6

6.1.1 Undergoes incomplete ionisation to produce a low concentration of hydronium ions ✓ (1)

6.1.2 INCREASES✓✓ (2)

6.2.1 Proton donor ✓ (1)

6.2.2 At the end of the reaction, **(7)**

$n(H^+) = c\,V$

$= (0,0461) \times 0,075$ ✓

$= 3,4575 \times 10^{-3}$ mol

$n(H^+)_{initial} = c\,V$ ✓

$= (0,1) \times (0,05)$ ✓

$= 5 \times 10^{-3}$

$n(H^+)$reacted with NaOH $= 5 \times 10^{-3} - 3,4575 \times 10^{-3}$ ✓✓

$n(NaOH) = 1,5425 \times 10^{-3}$ mol

$c(NaOH) = \frac{n}{V}$ ✓

$= \frac{1,5425}{0,025}$ ✓

$= 0,0617\ mol.dm^{-3}$. ✓

[11]

TOTAL: 75